

COMPETITIVE SPIRIT

Team Black Pearl of Bangladesh University of Engineering and Technology, victor in this year’s Worldwide Ferry Safety Association student design contest, shares how it put together the design for the winning concept for Lagos waterways

This year, the Worldwide Ferry Safety Association (WFSA) concluded its 12th International Maritime Student Design Competition, an annual initiative hosted to encourage students to create designs for safe, stable and affordable domestic ferries – and particularly for rivers and regions within developing countries, or which are prone to higher-than-average rates of accidents.

Previous instalments of the contest have focused on ferry designs for operations on the Pasig River in Manila; the Singapore Strait; the Amazon in Brazil (notably coinciding with the COVID pandemic, necessitating additional design measures to ensure safe passenger distancing); and the Savu Sea region in Indonesia, to name just a few locations. Last year, the contest called for a design for a ro-pax ferry for the River Niger in Nigeria, which was won by Team Nawasena from ITS, Indonesia (covered in depth in *Ship & Boat International* September/October 2024, pages 28-31).

As reported in that article, the Nigerian Inland Water Authority, which regulates some 3,000 waterways, has been working to combat an unacceptably high death toll – with 1,000 fatalities attributed to domestic ferry accidents in 2023 – within this network. Resolving these safety issues is critical for Nigeria – and particularly for its capital – given that, over the past three years, Lagos State (in which nearly a tenth of the 2023 fatalities were recorded) is rapidly expanding its public ferry system to relieve urban congestion.

Naija Spirit would run on a mix of batteries and hydrogen, with supplementary solar panels and an underwater hydrokinetic turbine



TECHNICAL PARTICULARS NAIJA SPIRIT

Length	28m (oa)
	27.2m (bp)
	27m (wl)
Breadth	9m
	2.7m (demi hull breadth)
Depth	2.7m
Draught	1.2m
Displacement	91.6tonnes
Service speed	20knots
Passengers	200

Contest specs

Dr Roberta Weisbrod, executive director of the WFSA, explains that the appetite for modernisation is strong in Lagos: “The Lagos State Waterways Authority [LASWA] oversees a network of 250 daily trips, 27 routes, 12 terminals and 44 jetties,” she comments. “In 2024, the state introduced 15 x 40-seater passenger waterbuses, built locally by Caverton Marine Limited, marking a milestone in Nigerian engineering and manufacturing.” Additionally, at COP28, Lagos obtained a €410 million grant to enhance its infrastructure, including the construction of new terminals and electric ferries.

Interestingly, the 12th WFSA student design contest saw the association return to Nigeria, with David Okafor, a naval architect with the Nigerian Navy, once again assisting in drawing up the specifications for the design teams.

This year’s challenge called for a 200-pax electric ferry capable of navigating Lagos’ waterways, emphasising a 25km route linking Ikorodu, a northeastern business zone, to the CMS transport hub on Lagos Island. The student teams had to factor



Team Black Pearl, from Bangladesh University of Engineering and Technology (BUET), winners of the 12th WFSA International Maritime Student Design Competition

Each WFSA student design contest brief presents unique challenges for teams. For Team Black Pearl, this year's contest involved overcoming a tight submission deadline and limited access to reliable, real-time data for the specified Lagos route.

in constraints such as low-clearance bridges, shallow docking depths (2.5m is common, Okafor advised) and water hyacinths, the latter of which can block ferry channels and jetties and cause damage to boat propellers and engines.

Project challenges

This year's winning entry was *Naija Spirit*, a 28m, double-deck aluminium catamaran, designed by Team Black Pearl of the Bangladesh University of Engineering and Technology (BUET). Team Black Pearl was captained by final-year student Md. Safayet Hossain Shishir – who, incidentally, was part of the BUET team that secured second-place in last year's WFSA River Niger design competition.

Shishir tells *The Naval Architect*:

"This edition of the competition allowed roughly three months to complete the entire project, which included everything from initial studies and literature reviews to developing preliminary plans, performing calculations, making critical design decisions and executing the final design. We overcame this challenge through effective coordination within the team, clearly assigning tasks with specific deadlines and managing our resources efficiently. Strong teamwork and structured planning were essential to delivering the project successfully within the limited timeframe."

Further, Shishir highlights, being based in Bangladesh made it difficult to obtain a comprehensive overview

MEET THE TEAM

Md. Safayet Hossain Shishir: a final-year naval architecture and marine engineering student at BUET, and team captain, Shishir kept Team Black Pearl on track, while contributing to the final principal particulars, trip time estimations, weight/scantlings calculations and the general arrangement.

Md. Abdul Kader: a postgraduate responsible for selecting the primary and auxiliary propulsion systems (including the battery system and hydrogen fuel cells) while overseeing renewable energy calculations, intact/damaged stability considerations and floodable length, seakeeping and manoeuvring analyses.

Abu Rasel: an undergraduate tasked with hull optimisation – ensuring high performance and low resistance – and *Naija Spirit*'s 3D-model visualisation, while also developing the ferry's aesthetics.

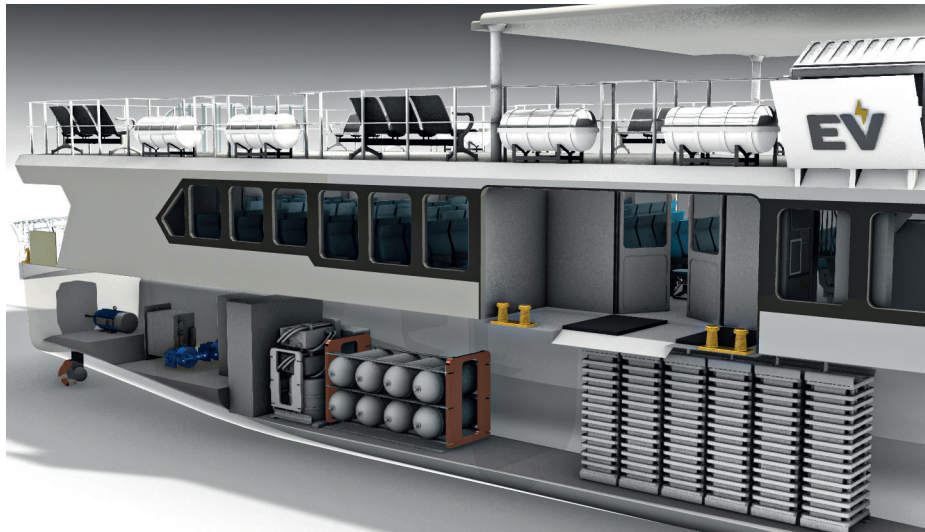
Mahmudul Hasan Shahed: an undergraduate managing the technical particulars and trip times, also responsible for cost analysis and estimations to ensure the ferry remained economically feasible.

Ajif Bin Habib Omeo: an undergraduate specialising in CFD, who analysed the ferry's resistance, propeller performance and passenger evacuation procedures.

Md. Kawsar Mhamud Zidan: an undergraduate who handled most of the ferry's 2D plan drawings in AutoCAD, while developing the outboard profile and life-saving equipment calculations.

Md. Atiqur Rahaman: an undergraduate who made an in-depth literature review of resources for the project, sharing this valuable info with the team, while assisting with weight, power and propulsion calculations.

The team was supervised by **Dr. Zobair Ibn Awal**, professor of naval architecture and marine engineering at BUET, who provided guidance and feedback.



The machinery space was fine-tuned to optimise power and distribute weight

of Lagos' riverine conditions. "To address this, we conducted extensive online research and gathered relevant information to ensure our design would be suitable for the region and aligned with international standards," he says. "For instance, we paid special attention to ensuring the ferry's speed would be competitive with local road transportation. To estimate road travel times accurately, we performed a detailed traffic analysis, using Google Maps over an entire day.

"This provided valuable insight into typical journey durations by road. Accordingly, we optimised our vessel's speed." However, despite these hurdles, the WFSA has always guided student participants rather than leaving them to navigate every problem on their own, as Shishir explains: "Additionally, support and prompt responses from Dr Weisbrod to our inquiries were instrumental in helping us progress effectively."

Electric arrangement

One of the most critical challenges, though, Shishir highlights, was the design of the vessel's electric battery pack. "It had to provide sufficient capacity for a complete round trip, while remaining as

lightweight as possible to maintain vessel efficiency," he says. "Another major focus was ensuring the ferry offered a clear travel time advantage over road transportation. This required identifying the optimal operating speed, minimising hydrodynamic resistance and targeting a one-way travel time of around 40 minutes.

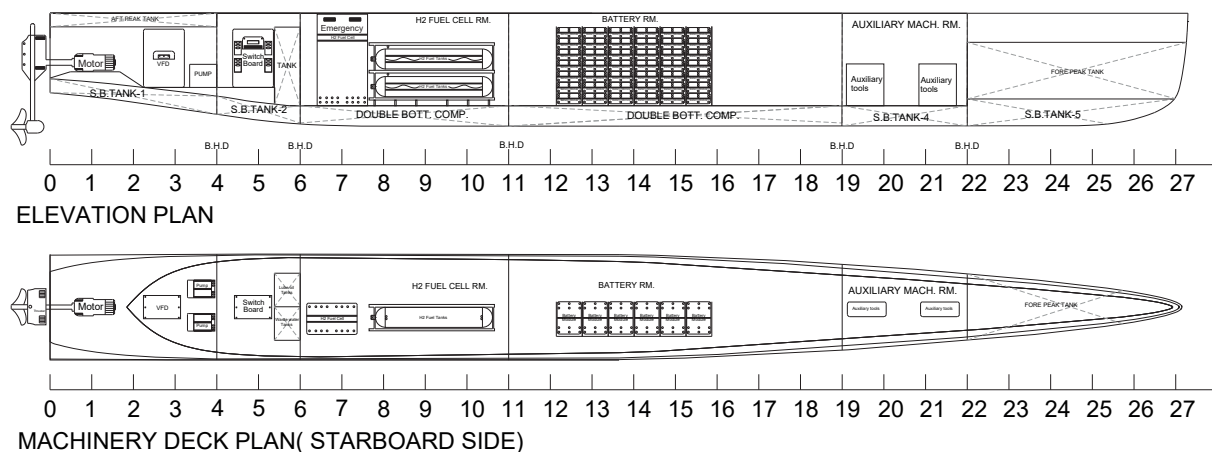
"Additionally, balancing charging time with battery weight posed a significant engineering challenge. Achieving the right trade-off was essential to ensure efficient turnaround, sustained performance and overall operational viability."

Naija Spirit would utilise an integrated electric propulsion system, comprising: two marine-grade, permanent magnet electric motors, rated 680kW at 1,200rpm apiece; a 584kW thruster with retractable, tilttable propellers; Sinus Penta 0457-series variable frequency drive inverters, with operating power bands spanning 1.3kW to 3,000kW; and switchboards provided by Stadt. The team also specified the use of ABB's marinised power cables.

The set-up would also incorporate a hydrogen fuel cell system, to serve as an emergency power source while avoiding greenhouse gas (GHG) emissions. Shishir explains: "In the event of a failure in the main propulsion system, the ferry will rely on the hydrogen fuel cells to maintain a speed of up to 14knots, ensuring it can safely reach the nearest terminal."

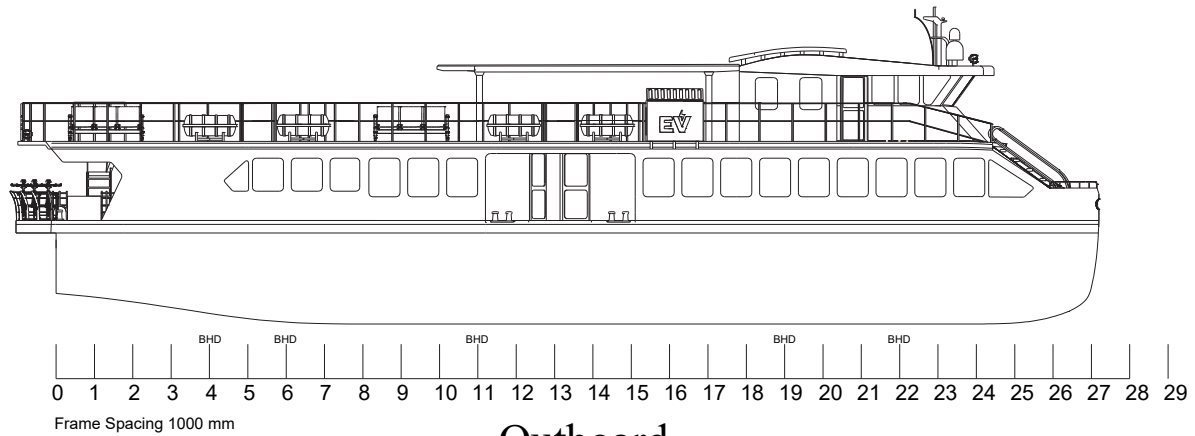
For *Naija Spirit*, the team chose two 1tonne Ballard hydrogen fuel cells, placed under the main deck at the demi hull. These would be paired with four Mahytec RGV500 hydrogen tanks, each with a 6.5kg

A diagram of the ferry's machinery space

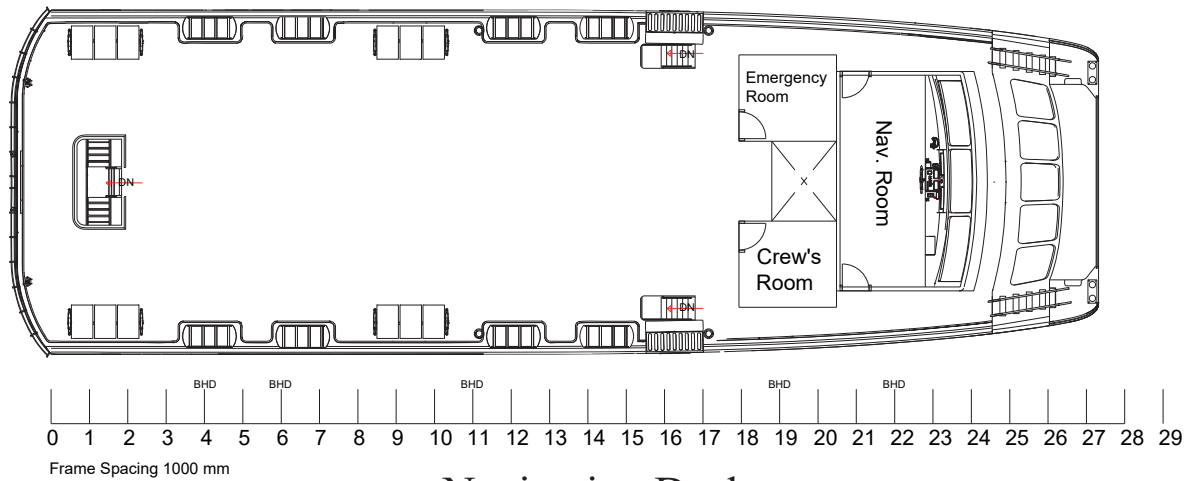




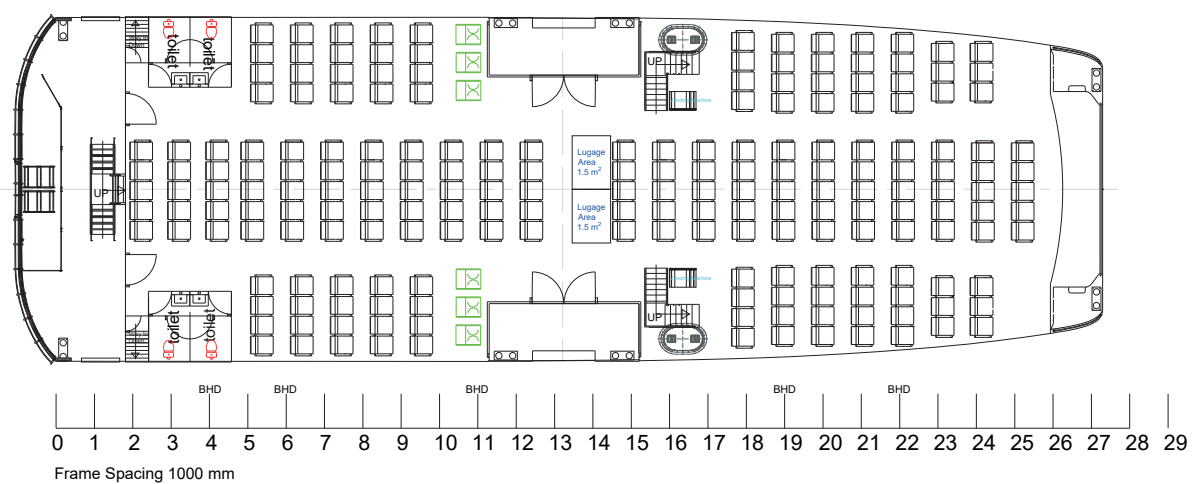
The general arrangement of *Naija Spirit*



Outboard



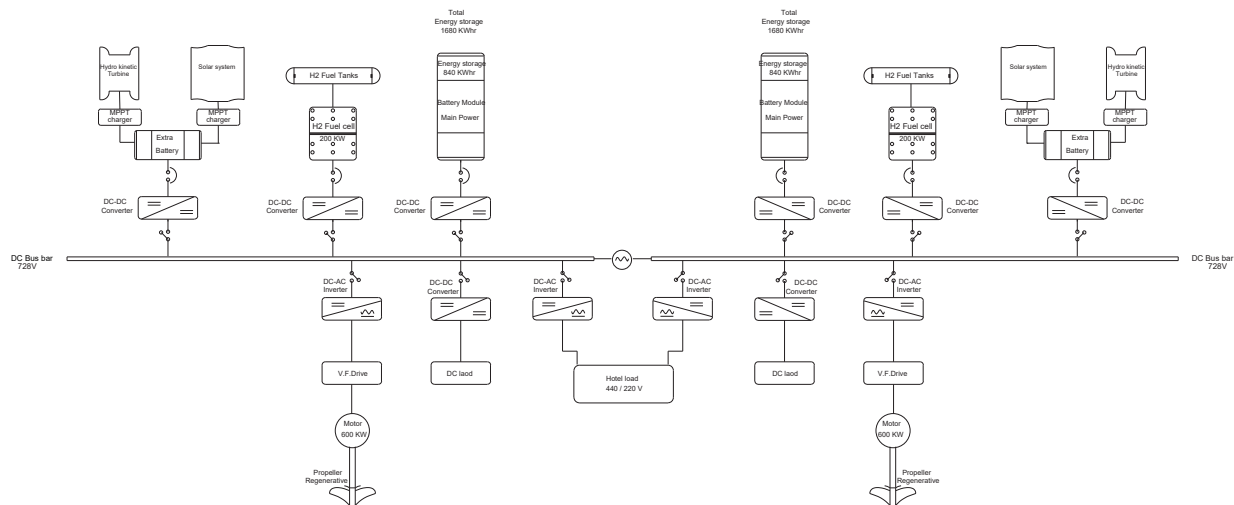
Navigation Deck



Main Deck



FEATURE FERRIES



A basic electric circuit diagram of the ferry, completed using IACS guidelines and drawing on ABS' 2022 DC power distribution systems for marine and offshore applications

capacity and weighing 0.185tonnes. Shishir adds: "Weight has always been a critical challenge...the main issue was finding a hydrogen fuel cell with a suitable height to fit within the under-deck space."

Team Black Pearl also calculated that 168 battery modules would be required, constituting a combined weight of 14.66tonnes. EST-Floattech's NMA-certified Octopus-branded batteries were selected. Shishir says: "The battery room is situated on the under deck." Due to the battery pack's weight, the room was "positioned around the midship, to ensure vessel stability", he explains, adding: "The battery spaces are isolated using watertight bulkheads, and designated in compartments in both demi hulls symmetrically, also maintaining structural integrity."

Speed and range

With the above propulsive arrangement, the team calculated that *Naija Spirit* would be capable of operating at a maximum speed of 20knots. "It can complete two trips – Ikorodu to CMS and back – covering 50km before requiring a recharge," Shishir says. "The ferry can complete up to 10 trips within the 12-hour operating window, from 6am to 6pm, covering approximately 250km in total."

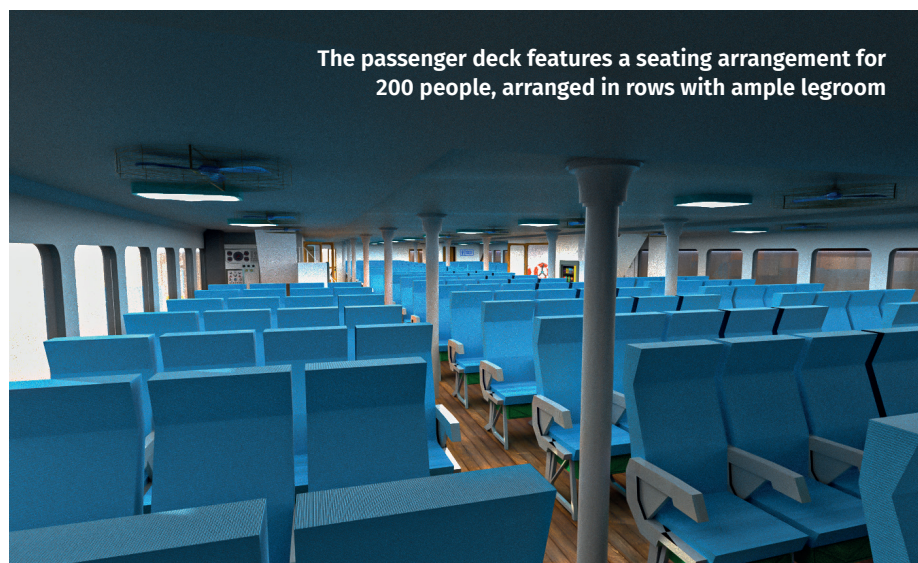
Other clean energy features include a 55m² spread of Solbian flexible solar panels, mounted on the roof and at points around the ferry. Each panel is rated 0.216kW, Shishir says, adding: "Assuming six hours of effective sunshine, the panels can generate a total of 71.28kWh – enough energy to power the ferry's hotel loads on that day." An additional 154kW of power would be generated by an underwater hydrokinetic

turbine "with a diameter equal to the ferry's draught, placed at the region of maximum flow velocity, identified by CFD analysis", Shishir adds.

The retractable propellers would feature a depth adjustment system, enabling the crew to adapt the propeller height in response to fluctuations in water depth or vessel load – while also hopefully reducing fuel consumption. Shishir says: "The fully retractable design, selected from an existing and proven configuration, protects the propeller even in the event of complete grounding, ensuring it remains undamaged. The entire propeller system operates hydraulically and is designed for ease of maintenance, featuring a user-friendly plug-and-play setup that allows the crew to service the system efficiently with minimal downtime."

Ferry stability

Naija Spirit's passenger deck features a seating arrangement for 200 people, arranged in rows with ample legroom. This deck would also feature vending machines, a luggage area and bicycle



The passenger deck features a seating arrangement for 200 people, arranged in rows with ample legroom

The team used Pathfinder software to simulate a full-ship evacuation

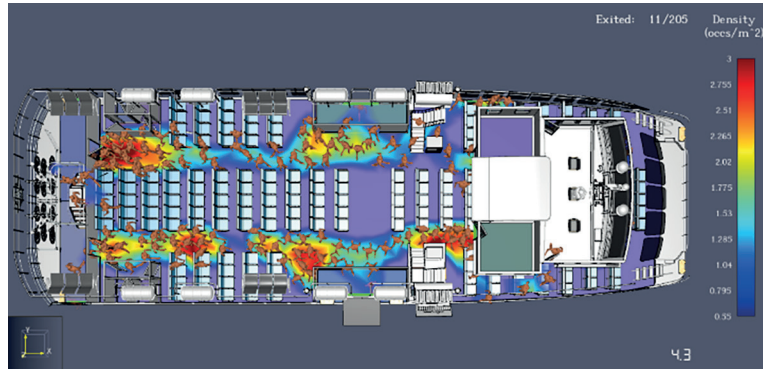
storage space at the aft. The navigation deck, meanwhile, would house the navigation room, a crew room and an emergency room. "The navigation deck is equipped with essential tools such as radar, GPS, electronic charts, VHF radios and signal lights, ensuring safe navigation and effective communication, even in adverse weather conditions," says Shishir.

Determining vessel stability was another important consideration, right down to the "careful arrangement of deck items", Shishir reveals, adding: "Even and symmetric general arrangement resulted in minimal vessel trim, and the number of watertight bulkheads was determined by floodable length analysis."

Intact stability analysis was conducted, taking into account severe wind and rolling. "Notably, the design passed the IMO rule [3.1.2.5] for passenger overcrowding criteria, which addresses one of the most critical safety concerns for passenger vessels," says Shishir. The team's damaged stability analysis was conducted in accordance with SOLAS 2009, specifically utilising MSC 216(82) guidelines for

passenger ships. "A total of 129 damage scenarios were analysed, including full damage cases, cases with 50% damage and one immediate case," he says. "The vessel successfully met all immersion angle criteria across these scenarios, and the GZ [righting arm] curves were calculated without any computational errors.

"Additionally, the attained index [A] of probabilistic damage stability surpassed the required threshold, confirming a high level of safety assurance. The analysis covered full load departure, ballast and lightship conditions, with the vessel compartmentalised into six zones and two horizontal decks to ensure detailed and robust stability evaluation."



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Although developed for Lagos waterways, the *Naija Spirit* concept could also benefit domestic operations in Bangladesh

To limit the draught to 1.2m, enabling the ferry to navigate Lagos' shallow waterways, the team optimised *Naija Spirit*'s hull design and weight distribution. "Its catamaran shape, with a wider beam, boosts buoyancy and stability without needing a deep draught," says Shishir. "Lightweight aluminium construction further reduces displacement."

Evacuation plan

And then, of course, there is the safety factor, the key driver of the WFSA contest. Shishir says that the team comprehensively drew up plans for potential pre-accident, accident and evacuation phases. *Naija Spirit* would be well-equipped with life-saving appliances, lifejackets (stowed under every passenger seat), a water sprinkler system, fire detectors and fire extinguishers. "Sufficient life rafts are positioned strategically near the entrance doors to help in the quick evacuation of passengers and crew," he says.

Team Black Pearl then used Pathfinder software to simulate a passenger evacuation. The simulation accounted for a full complement of 200 passengers, including 15 elderly persons and 20 children, plus five crew members guiding the evacuation.

"Two situations were tested," Shishir explains. "In the first, all exits were clear, and everyone evacuated in 6.41 minutes; in the second, a fire in the machinery space blocked the rear exits, and evacuation took 10.23 minutes. The ferry also has eight life rafts on the roof, each holding up to 25 people.

"These results meet the IMO safety rules, including the stricter evacuation time limits under MSC.123[75], and are well within the 25.07-minute limit set by the High-Speed Craft Code of 2000."

The ferry would also be fitted with directional sound beacon technology – a highly effective way of directing passengers to designated assembly areas, especially in conditions where visibility may be restricted by smoke, thus helping to prevent potentially fatal bottlenecks and overcrowding in particular onboard locations.

After the contest

So, having won the WFSA student design contest, could we see *Naija Spirit* come to fruition? One stumbling block at present is the lack of a suitable charging infrastructure at the Ikorodu and CMS terminals.

"Therefore, we analysed the existing power distribution companies in the vicinity of these terminals and identified some potential opportunities," says Shishir. "For example, the EKEDP [Lagos-based electricity provider] has large industrial capabilities to meet the energy demands of a shore-based charging station." He adds: "This presents a significant opportunity for the government and relevant stakeholders to explore further and make informed decisions to support this development. This step is crucial, not only for this project, but also for paving the way for a broader shift toward electric vessels."

To make it as simple as possible to build a physical version of *Naija Spirit*, the ferry would be assembled using pre-cut fabrication methods, making it easy to put together at local, established shipyards, such as Caverton Marine and Naval Dockyard Ltd.

Shishir concludes: "The Lagos government is prioritising a multimodal transportation system, which is expected to provide a solution to the country's heavy traffic congestion. As part of this initiative, they are promoting waterway ferry services and investing to offer a more sustainable solution.

"In many ways, this situation mirrors the challenges faced by our own country, Bangladesh, where similar traffic issues persist. We hope that, not only through this ferry design but also with the Nigerian government's vision and efforts to address these problems, we can draw valuable insights that could benefit Bangladesh as well. It is crucial that government officials step forward to engage in discussions and explore potential investment plans with relevant technical and economic stakeholders.

"We are eager to share our ideas with the Association of Naval Architects and Marine Engineers, Bangladesh and leading design firms, presenting our concepts and plans to help tackle this issue. We firmly believe that this is a fundamental challenge for most developing nations like Bangladesh, but we also see a glimmer of hope in utilising our riverine resources to create the most effective solution for the future of our nation."

In this way, rather than being a one-off, localised exercise, the WFSA student design contest has the capability to extend beyond borders, inspiring innovation and laying the foundations for what may prove to be the safe, energy-efficient domestic ferry designs of tomorrow. ■